

REMARKS

Claims 1-13 are pending in this application, with Claims 1, 7, and 13 being independent. In this Amendment After Final Rejection, Claims 1-13 have been amended.

The prior rejection of Claims 1, 5, 7 and 11 under 35 U.S.C. § 102(b) as allegedly anticipated by U.S. Patent No. 5,702,490 to Kneip, et al. (hereinafter "Kneip") or, in the alternative, under 35 U.S.C. § 103(a) as allegedly being unpatentable over Kneip was maintained. The prior rejection of Claims 2-4, 6, 8-10, and 12-13 under 35 U.S.C. § 103(a) as allegedly being unpatentable over Kneip was also maintained. Applicant respectfully traverses all art rejections. All amendments set forth herein are made for reasons of clarity with respect to the specification, and not for reasons relating to the statutory requirements for patentability.

Reconsideration and withdrawal of the outstanding rejections is respectfully requested in view of the remarks set forth below.

The Claimed Invention

The presently claimed invention relates to methods for treating textiles and leathers to impart water resistance, including the steps of applying to the textile a composition comprising a silicone emulsion, where said silicone consists essentially of pre-cured silicone. The textile is then dried.

The presently claimed invention wherein a silicone emulsion consisting essentially of pre-cured silicone is applied to the surface of a textile or leather has the benefit of not causing discoloration or damaging the surface finish. Treatment methods using uncured silicone compounds do not offer these benefits, regardless of whether heat treatment is used for curing. (See specification, page 1, lines 21-25.) Applicant teaches away from the use of uncured/non-crosslinked silicone compounds.

U.S. Patent No. 5,702,490 to Kneip

Kneip discloses a process for treating leathers/skins with carboxyl-containing polysiloxanes in an aqueous emulsion including emulsifiers, in order to impart water resistant properties in the leathers/skins. Kneip uses an emulsion containing polysiloxanes functionalized with side chains having spacer groups in the form of linear or branched alkylene groups having various substituents. It is disclosed at col. 2, lines 44-50, that the polysiloxanes are present as a *mixture of different forms*, including "chain polymers (generally main components of the mixtures), branched siloxanes, cyclic siloxanes **and** crosslinked siloxanes."

Applicant submits that the compositions disclosed in Kneip *do not* disclose methods of treating textiles or leathers using compositions comprising silicone emulsions, where the silicone consists essentially of precured silicone. As set forth above, Kneip discloses that although some crosslinked siloxanes are present, the main components of the emulsion of polysiloxanes are chain polymers. Branched siloxanes and cyclic siloxanes are also present. The silicone emulsion compositions of Kneip therefore do not disclose use of a silicone emulsion where the silicone consists essentially of cured/crosslinked silicone.

The Office Action insists that Applicant find a prior art teaching to show that "functionalized polysiloxanes encompass uncured/uncrosslinked siloxanes." However, this requirement is misplaced, because as Applicant set forth above, Kneip indicates that its functionalized polysiloxanes encompass uncured/uncrosslinked siloxanes in addition to some amount of crosslinked siloxanes, where the uncured/uncrosslinked chain polymers make up the main component of the polysiloxane emulsion.

Nevertheless, Applicant submits that it was well known to those skilled in the art at the time the invention was made that chain polysiloxanes, "functionalized with carboxyl groups in a comb-like manner and in which the carboxyl groups are bonded to the polymer main chain via spacer groups" (See Kneip, col. 1, 55-57), encompasses polysiloxanes that are not precured or crosslinked.

"Functional groups" were addressed by IUPAC in its Guide to IUPAC Nomenclature of Organic Compounds in 1993, in which the following explanation was given:

The prefixes and/or suffixes attached to a parent name specifying a particular molecular structure usually represent *substituents* of various types, which are considered to replace hydrogen atoms of a parent hydride or parent structure. It has been customary to regard such substituents as *characteristic* (or *functional*) when the link between the substituent and the parent is not a carbon-carbon bond, for example, -OH , =O , and -NH_2 , but many exceptions are recognized, such as -COOH and $\text{-C}\equiv\text{N}$. (See Exhibit A.)

Accordingly, the use of the term "functionalized" would be understood by one skilled in the art as merely referring to the fact that the polysiloxanes of Kneip are substituted with carboxyl groups along the main polymer chain. Functionalized polysiloxanes therefore encompasses any polysiloxane macromolecule having functional groups, which includes polysiloxanes that are not crosslinked or cured.

"Crosslinking" is defined in the Glossary of Basic Terms in Polymer Science originally proposed by IUPAC in 1974, and revised in 1996, as a small region in a macromolecule from which *at least four* chains emanate, and formed by reactions involving sites or groups on existing macromolecules or by interactions between existing macromolecules. (See Exhibit B, definition 1.59.) Nothing about the description of the polysiloxanes used in Kneip would indicate to one skilled in the art that the silicone emulsion applied to leathers as described therein consists essentially of precured/crosslinked silicone. The Glossary of Basic Terms in Polymer Science defines the "comb polymers" of Kneip as a polymers composed of "comb macromolecules," which are macromolecules comprising a main chain with multiple *trifunctional* "branch points" from each of which a linear "side chain" emanates.¹ (See Exhibit B, definition 1.52.) Kneip's use of carboxyl functional groups bonded to the main polymer chain via spacer groups, which are "equivalent to the teeth of the comb molecule" (Kneip, col. 2, lines 4-5) would be understood by one skilled in the art as a disclosure that only three

¹ The Glossary indicates in definition 1.54 that "[a] branch point from which f linear chains emanate may be termed an f-functional branch point, e.g., five-functional branch point. Alternatively, the terms trifunctional, tetrafunctional, pentafunctional, etc. may be used, e.g., pentafunctional branch point."

chains emanate from the branch point at each “tooth” of the comb molecule. The chain polysiloxanes having comb-like carboxyl functional groups disclosed in Kneip would be understood by one skilled in the art as not constituting crosslinked polysiloxanes.

Construction of “Consisting Essentially Of”

It is well-established in the case law that “the transitional phrase ‘consisting essentially of’ limits the scope of a claim to the specified materials or steps ‘and those that do not materially affect the basic and novel characteristic(s)’ of the claimed invention.” M.P.E.P. § 2111.03, *citing In re Herz*, 537 F.2d 549, 551-2, 190 USPQ 461, 463 (CCPA 1976). “For the purposes of searching for and applying prior art under 35 U.S.C. §§ 102 and 103, absent a clear indication in the specification or claims of what the basic and novel characteristics actually are, ‘consisting essentially of’ will be construed as equivalent to ‘comprising.’” M.P.E.P. § 2111.03, *citing PPG Industries v. Guardian Industries*, 156 F.3d 1351, 1354, 48 USPQ2d 1351, 1353-4 (Fed. Cir. 1998). “If an applicant contends that additional steps or materials in the prior art are excluded by the recitation of ‘consisting essentially of,’ applicant has the burden of showing that the introduction of additional steps or components would materially change the characteristics of applicant’s invention.” M.P.E.P. § 2111.03, *citing In re De Lajarte*, 337 F.2d 870, 143 USPQ 256 (CCPA 1964).

Applicant submits that it has met its burden of demonstrating that the claim language “consisting essentially of” should be read to exclude addition of uncured/non-crosslinked silicone compounds, which are described in the specification as causing undesirable discoloration and/or damage to the surface finish, regardless of curing process. Methods, such as those disclosed in Kneip, that require the application of compositions including uncured silicone compounds to the textile being treated, materially change the characteristics of the invention.

CONCLUSION

For at least the reasons set forth above, Applicant submits that Kneip does not disclose or suggest the claimed invention, and respectfully requests withdrawal of the outstanding rejections under 35 U.S.C. §§ 102(b) and 103(a). Applicant further submits that the presently claimed invention is allowable over the art of record, and respectfully requests prompt issuance of a notice thereof.

Applicant's undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 625-3500. All correspondence should continue to be directed to our address given below.

Respectfully submitted,

A handwritten signature in cursive script, reading "Dawn C. Hayes", is written over a horizontal line.

Attorney for Applicant
Dawn C. Hayes
Registration No. 44,751

Patent Administrator
KATTEN MUCHIN ZAVIS ROSENMAN
525 West Monroe Street
Suite 1600
Chicago, Illinois 60661-3693
Facsimile: (312) 906-1021

Recommendations 1993

R-3 Characteristic (Functional) Groups

R-3.0 Introduction

R-3.1 Unsaturation

R-3.2 Specification of Characteristic Groups

R-3.3 Functional Parent Compounds and Derived Substituent Groups

R-3.4 Functional Replacement



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Characteristic (Functional) Groups

R-3.0 Introduction

The prefixes and/or suffixes attached to a parent name specifying a particular molecular structure usually represent *substituents* of various types, which are considered to replace hydrogen atoms of a parent hydride or parent structure. It has been customary to regard such substituents as *characteristic* (or *functional*) when the link between substituent and parent is not a carbon-carbon bond, for example, $-\text{OH}$, $=\text{O}$, and $-\text{NH}_2$, but many exceptions are recognized, such as $-\text{COOH}$ and $-\text{C}\equiv\text{N}$. It seems appropriate at this time to retain the general view of *functionality* as implying the presence of heteroatoms and/or unsaturation, but it would not be helpful to attempt to define precisely the limits of application of the term.

Carbon-carbon unsaturation in acyclic species is regarded as a special type of functionality and it is therefore treated here in Section R-3 rather than in Section R-2 (Parent Hydrides); however, its presence here (and that of hydrogenation of parent hydrides containing the maximum number of noncumulative double bonds) is anomalous in that for some purposes, for example, choice of parent, it can be regarded as part of the parent; but for others, such as numbering, it is treated like a substituent.

Section R-3 also deals with *functional parents*, i.e., structures which are treated as parent structures, having substitutable hydrogen atoms, but which possess the characteristics normally associated with functionality [e.g., phosphonic acid $\text{HP}(\text{O})(\text{OH})_2$].

Although, strictly speaking, ions and radicals do not fall within the concept of functionality, as described above, an ionic centre or a radical centre is treated like a function, and this treatment is also included, therefore, here in Section R-3.

See Also:

[R-3.1 Unsaturation](#)

[R-3.2 Specification of Characteristic Groups](#)

[R-3.3 Functional Parent Compounds and Derived Substituent Groups](#)

[R-3.4 Functional Replacement](#)



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INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY
MACROMOLECULAR DIVISION
COMMISSION ON MACROMOLECULAR NOMENCLATURE*

GLOSSARY OF BASIC TERMS IN POLYMER SCIENCE

(IUPAC Recommendations 1996)

Prepared by a Working Group Consisting of

A. D. Jenkins (UK), P. Kratochvíl (Czech Republic),
R. F. T. Stepto (UK), and U. W. Suter (Switzerland)

* Membership of the Commission during the preparation of this report (1985-95) was as follows:

Titular Members: G. Allegra (Italy, to 1989); R. E. Bareiss (Germany, to 1993); N. M. Bikales (USA, Secretary to 1987); K. Harada (Japan, Associate Member from 1987, Titular Member from 1989); A. D. Jenkins (UK, *Chairman* to 1985, Associate Member to 1987); J. Kahovec (Czech Republic, Associate Member from 1987, Titular Member from 1991); P. Kratochvíl (Czech Republic, *Chairman* to 1991); E. Maréchal (France, Associate Member from 1991, Titular Member from 1993); W. V. Metzner (USA, Associate Member from 1987, Titular Member from 1991); I. Mita (Japan, Titular Member to 1989, Associate Member to 1991); C. Noël (France, to 1993); I. M. Papilov (Russia, to 1987, Associate Member to 1991); V. P. Shibaev (Russia, from 1987); R. F. T. Stepto (UK, Associate Member from 1987, Titular Member from 1989, *Chairman* from 1991); U. W. Suter (Switzerland, to 1991, Associate Member to 1993); W. I. Work (USA, Associate Member from 1985, Secretary from 1987).

Associate Members contributing to this report: J. V. Aleman (Spain, from 1987); M. Baron (Argentina, National Representative from 1987, Associate Member from 1991); J.-I. Jin (Korea, National Representative from 1991, Associate Member from 1993); K. Mayjuszewski (USA, from 1991); L. Shi (PR China, from 1987); F. Sigwalt (France, to 1987).

Others contributing to this report: H.-G. Elias (USA); R. B. Fox (USA); K. L. Loening (USA, National Representative to 1987); N.A. Platé (Russia, National Representative); A. Sirigu (Italy, National Representative); T. Tsuruta (Japan).

GLOSSARY OF BASIC TERMS IN POLYMER SCIENCE

(IUPAC Recommendations 1996)

SYNOPSIS

The clear and unambiguous definition of basic terms in a field of science has special significance. Subsequent nomenclature must refer back to these basic terms, and the utmost care is therefore required in preparing and revising them. In 1974, the Commission published a document entitled "Basic Definitions of Terms Relating to Polymers (1974)", that appeared in *Pure Appl. Chem.*, 1974, 46, 475–491. These definitions have been the foundation for the Commission's work and, building on this basis, the Commission has developed a number of further nomenclature documents. The vast majority of terms in the basic document serve their purpose well. Progress in polymer science and the need for new definitions, the proper wording of which would have been incompatible with some of the basic terms, made it increasingly apparent that some change was needed in the basic terms. Approximately twenty years since the publication of the first document, the Commission now issues a revised and enlarged set of basic terms. The new glossary of terms has been formulated by the Commission with the additional input and aid of several well-known researchers and journal editors.

PREAMBLE

In order to present clear concepts it is necessary that idealized definitions be adopted but it is recognized that the realities of polymer science must be faced. Deviations from ideality arise with polymers at both molecular and bulk levels in ways that have no parallel with the ordinary small molecules of organic or inorganic chemistry. Although such deviations are not explicitly taken into account in the definitions below, the nomenclature recommended can usefully be applied to the predominant structural features of real polymer molecules, if necessary with self-explanatory, if imprecise, qualifications such as "essentially...", "almost completely...", or "highly...". Although such expressions lack the rigour beloved by the purist, every experienced polymer scientist knows that communication in this discipline is impossible without them.

Conventionally, the word *polymer* used as a noun is ambiguous: it is commonly employed to refer to both polymer substances and polymer molecules. Henceforth, *macromolecule* is used for individual molecules and *polymer* is used to denote a substance composed of macromolecules. *Polymer* may also be employed unambiguously as an adjective, according to accepted usage, e.g. *polymer blend*, *polymer molecule*.

1. MOLECULES AND MOLECULAR STRUCTURE

1.1 macromolecule polymer molecule

A molecule of high relative molecular mass, the structure of which essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass.

Glossary of basic terms in polymer science

Notes

1. In many cases, especially for synthetic polymers, a molecule can be regarded as having a high relative molecular mass if the addition or removal of one or a few of the units has a negligible effect on the molecular properties. This statement fails in the case of certain macromolecules for which the properties may be critically dependent on fine details of the molecular structure.

2. If a part or the whole of the molecule has a high relative molecular mass and essentially comprises the multiple repetition of units derived, actually or conceptually, from molecules of low relative molecular mass, it may be described as either *macromolecular* or *polymeric*, or by *polymer* used adjectivally.

1.2 oligomer molecule

A molecule of intermediate relative molecular mass, the structure of which essentially comprises a small plurality of units derived, actually or conceptually, from molecules of lower relative molecular mass.

Notes

1. A molecule is regarded as having an intermediate relative molecular mass if it has properties which do vary significantly with the removal of one or a few of the units.

2. If a part or the whole of the molecule has an intermediate relative molecular mass and essentially comprises a small plurality of units derived, actually or conceptually, from molecules of lower relative molecular mass, it may be described as *oligomeric*, or by *oligomer* used adjectivally.

1.3 monomer molecule

A molecule which can undergo polymerization (see Definition 3.1), thereby contributing constitutional units (see Definition 1.14) to the essential structure of a macromolecule (see Definition 1.1).

1.4 regular macromolecule

A macromolecule (see Definition 1.1), the structure of which essentially comprises the repetition of a single constitutional unit (see Definition 1.14) with all units connected identically with respect to directional sense.

1.5 irregular macromolecule

A macromolecule (see Definition 1.1), the structure of which essentially comprises the repetition of more than one type of constitutional unit (see Definition 1.14), or a macromolecule the structure of which comprises constitutional units not all connected identically with respect to directional sense.

1.6 linear macromolecule

A macromolecule (see Definition 1.1), the structure of which essentially comprises the multiple repetition in linear sequence of units derived, actually or conceptually, from molecules of low relative molecular mass.

- 1.7 regular oligomer molecule**
An oligomer molecule (see Definition 1.2), the structure of which essentially comprises the repetition of a single constitutional unit (see Definition 1.14) with all units connected identically with respect to directional sense.
- 1.8 monomeric unit**
monomer
The largest constitutional unit (see Definition 1.14) contributed by a single monomer molecule (see Definition 1.3) to the structure of a macromolecule (see Definition 1.1) or oligomer molecule (see Definition 1.2).
Note
The largest constitutional unit contributed by a single monomer molecule to the structure of a macromolecule or oligomer molecule may be described as either monomeric, or by monomer used adjectivally.
- 1.9 macromonomer molecule**
A macromolecule (see Definition 1.1) that has one end-group which enables it to act as a monomer molecule (see Definition 1.3), contributing only a single monomeric unit (see Definition 1.8) to a chain of the final macromolecule.
- 1.10 macroradical**
A macromolecule (see Definition 1.1) which is also a free radical.
- 1.11 pre-polymer molecule**
A macromolecule (see Definition 1.1) or oligomer molecule (see Definition 1.2) capable of entering, through reactive groups, into further polymerization (see Definition 3.1), thereby contributing more than one monomeric unit (see Definition 1.8) to at least one chain of the final macromolecule.
Note
A pre-polymer molecule capable of entering into further polymerization through reactive end-groups (see Definition 1.35), often deliberately introduced, is known as a telechelic molecule.
- 1.12 macromonomeric unit**
macromonomer unit
The largest constitutional unit (see Definition 1.14) contributed by a single macromonomer molecule (see Definition 1.9) to the structure of a macromolecule (see Definition 1.1).
- 1.13 degree of polymerization**
The number of monomeric units (see Definition 1.8) in a macromolecule (see Definition 1.1) an oligomer molecule (see Definition 1.2), a block (see Definition 1.62), or a chain (see Definition 1.30).

- 1.14 constitutional unit**
An atom or group of atoms (with pendant atoms or groups, if any) comprising a part of the essential structure of a macromolecule (see Definition 1.1), an oligomer molecule (see Definition 1.2), a block (see Definition 1.62), or a chain (see Definition 1.30).
- 1.15 constitutional repeating unit (CRU)**
The smallest constitutional unit (see Definition 1.14), the repetition of which constitutes a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30).
- 1.16 configurational unit**
A constitutional unit (see Definition 1.14) having at least one site of defined stereoisomerism.
- 1.17 configurational base unit**
A constitutional repeating unit (see Definition 1.15) in a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30), the configuration of which is defined at least at one site of stereoisomerism in the main chain (see Definition 1.34).
- 1.18 configurational repeating unit**
The smallest set of successive configurational base units (see Definition 1.17) that prescribes configurational repetition at one or more sites of stereoisomerism in the main chain (see Definition 1.34) of a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30).
- 1.19 stereorepeating unit**
A configurational repeating unit (see Definition 1.18) having defined configuration at all sites of stereoisomerism in the main chain (see Definition 1.34) of a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30).
- 1.20 tacticity**
The orderliness of the succession of configurational repeating units (see Definition 1.18) in the main chain (see Definition 1.34) of a regular macromolecule (see Definition 1.4), a regular oligomer molecule (see Definition 1.7), a regular block (see Definition 1.62), or a regular chain (see Definition 1.30).
- 1.21 tactic macromolecule**
A regular macromolecule (see Definition 1.4) in which essentially all the configurational (repeating) units (see Definitions 1.16 and 1.18) are identical.
- 1.22 stereoregular macromolecule**
A regular macromolecule (see Definition 1.4) essentially comprising only one species of stereorepeating unit (see Definition 1.19).

1.23 isotactic macromolecule

A tactic macromolecule (see Definition 1.21), essentially comprising only one species of configurational base unit (see Definition 1.17), which has chiral or prochiral atoms in the main chain (see Definition 1.34) in a unique arrangement with respect to its adjacent constitutional units (see Definition 1.14).

Notes

1. In an isotactic macromolecule, the configurational repeating unit (see Definition 1.16) is identical with the configurational base unit.
2. An isotactic macromolecule consists of meso diads (see Definition 1.64).

1.24 syndiotactic macromolecule

A tactic macromolecule (see Definition 1.21), essentially comprising alternating enantiomeric configurational base units (see Definition 1.17), which have chiral or prochiral atoms in the main chain (see Definition 1.34) in a unique arrangement with respect to their adjacent constitutional units (see Definition 1.14).

Notes

1. In a syndiotactic macromolecule, the configurational repeating unit consists of two configurational base units that are enantiomeric.
2. A syndiotactic macromolecule consists of racemo diads (see Definition 1.64).

1.25 atactic macromolecule

A regular macromolecule (see Definition 1.4) in which the configurational (base) units (see Definitions 1.16 and 1.17) are not all identical.

1.26 block macromolecule

A macromolecule (see Definition 1.1) which is composed of blocks (see Definition 1.62) in linear sequence.

1.27 junction unit

A non-repeating atom or non-repeating group of atoms between blocks in a block macromolecule (see Definition 1.26).

1.28 graft macromolecule

A macromolecule (see Definition 1.1) with one or more species of block (see Definition 1.62) connected to the main chain (see Definition 1.34) as side-chains (see Definition 1.53), these side-chains having constitutional or configurational features that differ from those in the main chain.

1.29 stereoblock macromolecule

A block macromolecule (see Definition 1.26) composed of stereoregular, and possibly non-stereoregular, blocks (see Definition 1.62).

1.30 chain

The whole or part of a macromolecule (see Definition 1.1), an oligomer molecule (see Definition 1.2), or a block (see Definition 1.62), comprising a linear or branched sequence of constitutional units (see Definition 1.14) between two boundary constitutional units, each of which may be either an end-group (see Definition 1.35), a branch point (see Definition 1.54), or an otherwise-designated characteristic feature of the macromolecule.

Notes

1. Except in linear single-strand macromolecules (see Definition 1.39), the definition of a chain may be somewhat arbitrary.
2. A cyclic macromolecule has no end-groups but may nevertheless be regarded as a chain.
3. Any number of branch points may be present between the boundary units.
4. Where appropriate, definitions relating to *macromolecule* may also be applied to *chain*.

1.31 subchain

An arbitrarily chosen contiguous sequence of constitutional units (see Definition 1.14) in a chain (see Definition 1.30).

Note

The term *subchain* may be used to define designated subsets of the constitutional units in a chain.

1.32 linear chain

A chain (see Definition 1.30) with no branch points (see Definition 1.54) intermediate between the boundary units.

1.33 branched chain

A chain (see Definition 1.30) with at least one branch point (see Definition 1.54) intermediate between the boundary units.

1.34 main chain**backbone**

That linear chain (see Definition 1.32) to which all other chains, long (see Definition 1.36) or short (see Definition 1.37) or both, may be regarded as being pendant.

Note

Where two or more chains could equally be considered to be the main chain, that one is selected which leads to the simplest representation of the molecule.

1.35 end-group

A constitutional unit (see Definition 1.14) that is an extremity of a macromolecule (see Definition 1.1) or oligomer molecule (see Definition 1.2).

Note

An end-group is attached to only one constitutional unit of a macromolecule or oligomer molecule.

1.36 long chain

A chain (see Definition 1.30) of high relative molecular mass.

Note

See Note 1 to Definition 1.1.

1.37 short chain

A chain (see Definition 1.30) of low relative molecular mass.

Note

See Note 1 to Definition 1.2.

1.38 single-strand chain

A chain (see Definition 1.30) that comprises constitutional units (see Definition 1.14) connected in such a way that adjacent constitutional units are joined to each other through two atoms, one on each constitutional unit.

1.39 single-strand macromolecule

A macromolecule (see Definition 1.1) that comprises constitutional units (see Definition 1.14) connected in such a way that adjacent constitutional units are joined to each other through two atoms, one on each constitutional unit.

1.40 double-strand chain

A chain (see Definition 1.30) that comprises constitutional units (see Definition 1.14) connected in such a way that adjacent constitutional units are joined to each other through three or four atoms, two on one side and either one or two on the other side of each constitutional unit.

1.41 double-strand macromolecule

A macromolecule (see Definition 1.1) that comprises constitutional units (see Definition 1.14) connected in such a way that adjacent constitutional units are joined to each other through three or four atoms, two on one side and either one or two on the other side of each constitutional unit.

1.42 spiro chain

A double-strand chain (see Definition 1.40) consisting of an uninterrupted sequence of rings, with adjacent rings having only one atom in common.

Note

A spiro chain is a double-strand chain (see Definition 1.40) with adjacent constitutional units (see Definition 1.14) joined to each other through three atoms, two on one side and one on the other side of each constitutional unit.

1.43 spiro macromolecule

A double-strand macromolecule (see Definition 1.41) consisting of an uninterrupted sequence of rings, with adjacent rings having only one atom in common.

Note

A spiro macromolecule is a double-strand macromolecule (see Definition 1.41) with adjacent constitutional units (see Definition 1.14) joined to each other through three atoms, two on one side and one on the other side of each constitutional unit.

1.44 ladder chain

A double-strand chain (see Definition 1.40) consisting of an uninterrupted sequence of rings, with adjacent rings having two or more atoms in common.

Note

A ladder chain is a double-strand chain (see Definition 1.40) with adjacent constitutional units (see Definition 1.14) joined to each other through four atoms, two on one side and two on the other side of each constitutional unit.

1.45 ladder macromolecule

A double-strand macromolecule (see Definition 1.41) consisting of an uninterrupted sequence of rings, with adjacent rings having two or more atoms in common.

Note

A ladder macromolecule is a double-strand macromolecule (see Definition 1.41) with adjacent constitutional units (see Definition 1.14) joined to each other through four atoms, two on one side and two on the other side of each constitutional unit.

1.46 multi-strand chain

A chain (see Definition 1.30) that comprises constitutional units (see Definition 1.14) connected in such a way that adjacent constitutional units are joined to each other through more than four atoms, more than two on at least one side of each constitutional unit.

Note

A chain that comprises constitutional units joined to each other through n atoms on at least one side of each constitutional unit is termed an n -strand chain, e.g., three-strand chain. If an uncertainty exists in defining n , the highest possible number is selected.

1.47 multi-strand macromolecule

A macromolecule (see Definition 1.1) that comprises constitutional units (see Definition 1.14) connected in such a way that adjacent constitutional units are joined to each other through more than four atoms, more than two on at least one side of each constitutional unit.

Note

A macromolecule that comprises constitutional units joined to each other through n atoms on at least one side of each constitutional unit is termed an n -strand macromolecule, e.g., three-strand macromolecule. If an ambiguity exists in defining n , the highest possible number is selected.

1.48 skeletal structure

The sequence of atoms in the constitutional unit(s) (see Definition 1.14) of a macromolecule (see Definition 1.1), an oligomer molecule (see Definition 1.2), a block (see Definition 1.62), or a chain (see Definition 1.30), which defines the essential topological representation.

Glossary of basic terms in polymer science

- 1.49 skeletal atom**
An atom in a skeletal structure (see Definition 1.48).
- 1.50 skeletal bond**
A bond connecting two skeletal atoms (see Definition 1.49).
- 1.51 star macromolecule**
A macromolecule (see Definition 1.1) containing a single branch point (see Definition 1.54) from which linear chains (see Definition 1.32) (arms) emanate.
- Notes*
1. A star macromolecule with n linear chains (arms) attached to the branch point is termed an n -star macromolecule, e.g., five-star macromolecule.
 2. If the arms of a star macromolecule are identical with respect to constitution and degree of polymerization, the macromolecule is termed a **regular star macromolecule**.
 3. If different arms of a star macromolecule are composed of different monomeric units, the macromolecule is termed a **variegated star macromolecule**.
- 1.52 comb macromolecule**
A macromolecule (see Definition 1.1) comprising a main chain (see Definition 1.34) with multiple trifunctional branch points (see Definition 1.54) from each of which a linear side-chain (see Definition 1.53) emanates.
- Notes*
1. If the subchains between the branch points of the main chain and the terminal subchains of the main chain are identical with respect to constitution and degree of polymerization, and the side chains are identical with respect to constitution and degree of polymerization (see Definition 1.13), the macromolecule is termed a **regular comb macromolecule**.
 2. If at least some of the branch points are of functionality greater than three, the macromolecule may be termed a **brush macromolecule**.
- 1.53 branch**
side-chain
pendant chain
An oligomeric (see Definition 1.2) or polymeric (see Definition 1.1) offshoot from a macromolecular (see Definition 1.1) chain (see Definition 1.30).
- Notes*
1. An oligomeric branch may be termed a **short-chain branch**.
 2. A polymeric branch may be termed a **long-chain branch**.
- 1.54 branch point**
A point on a chain (see Definition 1.30) at which a branch (see Definition 1.53) is attached.
- Notes*
1. A branch point from which linear chains emanate may be termed an **f-functional branch point**, e.g., five-functional branch point. Alternatively, the terms trifunctional,

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- tetrafunctional, pentafunctional, etc. may be used, e.g., pentafunctional branch point.
2. A branch point in a network may be termed a **junction point**.
- 1.55 branch unit**
A constitutional unit (see Definition 1.14) containing a branch point (see Definition 1.54).
- Note*
A branch unit from which linear chains emanate may be termed an **f-functional branch unit**, e.g., five-functional branch unit. Alternatively, the terms trifunctional, tetrafunctional, pentafunctional, etc. may be used, e.g., pentafunctional branch unit.
- 1.56 pendant group**
side-group
An offshoot, neither oligomeric (see Definition 1.2) nor polymeric (see Definition 1.1), from a chain (see Definition 1.30).
- 1.57 macrocycle**
A cyclic macromolecule (see Definition 1.1) or a macromolecular cyclic portion of a macromolecule.
- Notes*
1. See Note 2 to Definition 1.30.
 2. In the literature, the term **macrocycle** is sometimes used for molecules of low relative molecular mass that would not be considered *macromolecules* as specified in Definition 1.1.
- 1.58 network**
A highly ramified macromolecule (see Definition 1.1) in which essentially each constitutional unit (see Definition 1.14) is connected to each other constitutional unit and to the macroscopic phase boundary by many permanent paths through the macromolecule, the number of such paths increasing with the average number of intervening bonds; the paths must on the average be co-extensive with the macromolecule.
- Notes*
1. Usually, and in all systems that exhibit rubber elasticity, the number of distinct paths is very high, but, in most cases, some constitutional units exist which are connected by a single path only.
 2. If the permanent paths through the structure of a network are all formed by covalent bonds, the term **covalent network** may be used.
 3. The term **physical network** may be used if the permanent paths through the structure of a network are not all formed by covalent bonds but, at least in part, by physical interactions, such that removal of the interactions leaves individual macromolecules or a macromolecule that is not a network.
- 1.59 crosslink**
A small region in a macromolecule (see Definition 1.1) from which at least four chains (see Definition 1.30) emanate, and formed by reactions involving sites or groups on existing macromolecules or by interactions between existing macromolecules.

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Notes

1. The small region may be an atom, a group of atoms, or a number of branch points connected by bonds, groups of atoms, or oligomeric chains.
2. In the majority of cases, a crosslink is a covalent structure but the term is also used to describe sites of weaker chemical interactions, portions of crystallites, and even physical interactions and entanglements.

1.60 micronetwork

A highly ramified macromolecule (see Definition 1.1) that contains cyclic structures and is of colloidal dimensions.

1.61 loose end

A chain (see Definition 1.30), only one point of which is attached to a network (see Definition 1.56).

1.62 block

A portion of a macromolecule (see Definition 1.1), comprising many constitutional units (see Definition 1.14), that has at least one feature which is not present in the adjacent portions.

Note

Where appropriate, definitions relating to *macromolecule* may also be applied to *block*.

1.63 constitutional sequence

The whole or part of a chain (see Definition 1.30) comprising one or more species of constitutional unit(s) (see Definition 1.14) in defined sequence.

Note

Constitutional sequences comprising two constitutional units are termed *diads*, those comprising three constitutional units *triads*, and so on. In order of increasing sequence lengths they are called *tetrads*, *pentads*, *hexads*, *heptads*, *octads*, *nonads*, *decads*, *undecads*, etc.

1.64 configurational sequence

The whole or part of a chain (see Definition 1.30) comprising one or more species of configurational unit(s) (see Definition 1.16) in defined sequence.

Note

Configurational sequences comprising two configurational units are termed *diads*, those with three such configurational units *triads*, and so on. In order of increasing sequence lengths they are called *tetrads*, *pentads*, *hexads*, *heptads*, *octads*, *nonads*, *decads*, *undecads*, etc.

1.65 polyelectrolyte molecule

A macromolecule (see Definition 1.1) in which a substantial portion of the constitutional units (see Definition 1.14) have ionizable or ionic groups, or both.

1.66 ionomer molecule

A macromolecule (see Definition 1.1) in which a small but significant proportion of the constitutional units (see Definition 1.14) have ionizable or ionic groups, or both.

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Note

Some protein molecules may be classified as ionomer molecules.

2. SUBSTANCES

2.1 monomer

A substance composed of monomer molecules (see Definition 1.3).

2.2 polymer

A substance composed of macromolecules (see Definition 1.1).

2.3 oligomer

A substance composed of oligomer molecules (see Definition 1.2).

Note

An oligomer obtained by telomerization (see Definition 3.2) is often termed a *telomer*.

2.4 homopolymer

A polymer (see Definition 2.2) derived from one species of (real, implicit or hypothetical) monomer (see Definition 2.1).

Notes

1. Many polymers are made by the mutual reaction of complementary monomers. These monomers can readily be visualized as reacting to give an "implicit monomer", the homopolymerization of which would give the actual product, which can be regarded as a homopolymer. Common examples are poly(ethylene terephthalate) and poly(hexamethylene adipamide).
2. Some polymers are obtained by the chemical modification of other polymers such that the structure of the macromolecules that constitute the resulting polymer can be thought of as having been formed by the homopolymerization of a hypothetical monomer. These polymers can be regarded as homopolymers. Example: poly(vinyl alcohol).

2.5 copolymer

A polymer (see Definition 2.2) derived from more than one species of monomer (see Definition 2.1).

Note

Copolymers that are obtained by copolymerization (see Definition 3.4) of two monomer species are sometimes termed *bipolymers*, those obtained from three monomers *terpolymers*, those obtained from four monomers *quaterpolymers*, etc..

2.6 pseudo-copolymer

An irregular polymer (see Definition 2.16), the molecules of which are derived from only one species of monomer (see Definition 2.1) but which display a variety of structural features more appropriate for description in copolymer (see Definition 2.5) terms.

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Note

Where appropriate, adjectives specifying the types of copolymer may be applied to *pseudo-copolymer*. The term *statistical pseudo-copolymer*, for instance, may be used to describe an irregular polymer in the molecules of which the sequential distribution of configurational units obeys known statistical laws (see Definition 2.9).

2.7

co-oligomer

An oligomer (see Definition 2.3) derived from more than one species of monomer (see Definition 2.1).

2.8

pseudo-co-oligomer

An irregular oligomer (see Definition 2.3), the molecules of which are derived from only one species of monomer (see Definition 2.1) but which display a variety of structural features more appropriate for description in co-oligomer (see Definition 2.7) terms.

2.9

statistical copolymer

A copolymer (see Definition 2.5) consisting of macromolecules (see Definition 1.1) in which the sequential distribution of the monomeric units (see Definition 1.8) obeys known statistical laws.

Note

An example of a statistical copolymer is one consisting of macromolecules in which the sequential distribution of monomeric units follows Markovian statistics.

2.10

random copolymer

A copolymer (see Definition 2.5) consisting of macromolecules (see Definition 1.1) in which the probability of finding a given monomeric unit (see Definition 1.8) at any given site in the chain (see Definition 1.30) is independent of the nature of the adjacent units.

Note

In a random copolymer, the sequence distribution of monomeric units follows Bernoullian statistics.

2.11

alternating copolymer

A copolymer (see Definition 2.5) consisting of macromolecules (see Definition 1.1) comprising two species of monomeric units (see Definition 1.8) in alternating sequence.

Note

An alternating copolymer may be considered as a homopolymer derived from an implicit or hypothetical monomer; see Note 1 to Definition 2.4.

2.12

periodic copolymer

A copolymer (see Definition 2.5) consisting of macromolecules (see Definition 1.1) comprising more than two species of monomeric units (see Definition 1.8) in regular sequence.

2.13

uniform polymer**monodisperse polymer**

A polymer (see Definition 2.2) composed of molecules uniform with respect to relative molecular mass and constitution.

Notes

1. A polymer comprising a mixture of linear (see Definition 1.32) and branched (see Definition 1.33) chains, all of uniform relative molecular mass, is not uniform.
2. A copolymer comprising linear molecules of uniform relative molecular mass and uniform elemental composition but different sequential arrangements of the various types of monomeric units (see Definition 1.8), is not uniform (e.g., a copolymer comprising molecules with a random arrangement as well as a block arrangement of monomeric units).
3. A polymer uniform with respect only to either relative molecular mass or constitution may be termed uniform, provided a suitable qualifier is used (e.g., "a polymer uniform with respect to relative molecular mass").
4. The adjectives *monodisperse* and *polydisperse* are deeply rooted in the literature, despite the former being non-descriptive and self-contradictory. They are in common usage and it is recognized that they will continue to be used for some time; nevertheless, more satisfactory terms are clearly desirable. After an extensive search for possible replacements, the terms *uniform* and *non-uniform* have been selected and they are now the preferred adjectives.

2.14

non-uniform polymer**polydisperse polymer**

A polymer (see Definition 2.2) comprising molecules non-uniform with respect to relative molecular mass or constitution or both.

Note

See Notes 3 and 4 to Definition 2.13.

2.15

regular polymer

A polymer composed of regular macromolecules (see Definition 1.4), regular star macromolecules (see Definition 1.51), or regular comb macromolecules (see Definition 1.52).

Note

A polymer consisting of star macromolecules with arms identical with respect to constitution and degree of polymerisation is considered to be regular; see Note 2 to Definition 1.51. Analogously, a polymer consisting of comb macromolecules with the sub-chains between the branch points of the main chain and the terminal sub-chains of the main chain identical with respect to constitution and degree of polymerisation and the side-chains identical with respect to constitution and degree of polymerisation is considered to be regular; see Note 1 to Definition 1.52.

2.16

irregular polymer

A polymer composed of irregular macromolecules (see Definition 1.5).

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- 2.17 tactic polymer**
A polymer composed of tactic macromolecules (see Definition 1.21).
- 2.18 isotactic polymer**
A polymer composed of isotactic macromolecules (see Definition 1.23).
- 2.19 syndiotactic polymer**
A polymer composed of syndiotactic macromolecules (see Definition 1.24).
- 2.20 stereoregular polymer**
A polymer composed of stereoregular macromolecules (see Definition 1.22).
- 2.21 atactic polymer**
A polymer composed of atactic macromolecules (see Definition 1.25).
- 2.22 block polymer**
A polymer composed of block macromolecules (see Definition 1.26).
- 2.23 graft polymer**
A polymer composed of graft macromolecules (see Definition 1.28).
- 2.24 block copolymer**
A copolymer (see Definition 2.5) that is a block polymer (see Definition 2.23).
Note
In the constituent macromolecules of a block copolymer, adjacent blocks are constitutionally different, i.e., adjacent blocks comprise constitutional units (see Definition 1.14) derived from different species of monomer (see Definition 2.1) or from the same species of monomer but with a different composition or sequence distribution of constitutional units.
- 2.25 graft copolymer**
A copolymer (see Definition 2.5) that is a graft polymer (see Definition 2.23).
Note
In the constituent macromolecules of a graft copolymer, adjacent blocks in the main chain or side-chains or both, are constitutionally different, i.e., adjacent blocks comprise constitutional units (see Definition 1.14) derived from different species of monomer (see Definition 2.1) or from the same species of monomer but with a different composition or sequence distribution of constitutional units.
- 2.26 stereoblock polymer**
A polymer composed of stereoblock macromolecules (see Definition 1.29).

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- 2.27 linear polymer**
A polymer (see Definition 2.2) composed of linear macromolecules (see Definition 1.6).
- 2.28 linear copolymer**
A copolymer (see Definition 2.5) composed of linear macromolecules (see Definition 1.6).
- 2.29 single-strand polymer**
A polymer (see Definition 2.2), the macromolecules (see Definition 1.1) of which are single-strand macromolecules (see Definition 1.39).
- 2.30 double-strand polymer**
A polymer (see Definition 2.2), the macromolecules (see Definition 1.1) of which are double-strand macromolecules (see Definition 1.41).
Notes
1. A polymer, the macromolecules of which are spiro macromolecules (see Definition 1.43), is termed a *spiro polymer*.
2. A polymer, the macromolecules of which are ladder macromolecules (see Definition 1.45), is termed a *ladder polymer*.
- 2.31 double-strand copolymer**
A copolymer (see Definition 2.5), the macromolecules (see Definition 1.1) of which are double-strand macromolecules (see Definition 1.41).
- 2.32 star polymer**
A polymer composed of star macromolecules (see Definition 1.51).
- 2.33 comb polymer**
A polymer composed of comb macromolecules (see Definition 1.52).
Note
See the Notes to Definitions 1.52 and 2.15.
- 2.34 branched polymer**
A polymer (see Definition 2.2), the molecules of which are branched chains (see Definition 1.33).
- 2.35 macromonomer**
A polymer composed of macromonomer molecules (see Definition 1.9).
- 2.36 mesogenic monomer**
A monomer (see Definition 2.1) which can impart the properties of liquid crystals to the polymers (see Definition 2.2) formed by its polymerization (see Definition 3.1).

- 2.37 pre-polymer**
A polymer or oligomer composed of pre-polymer molecules (see Definition 1.11).
- 2.38 polyelectrolyte**
A polymer composed of polyelectrolyte molecules (see Definition 1.65).
- 2.39 ionomer**
A polymer composed of ionomer molecules (see Definition 1.66).
- 2.40 polymer blend**
A macroscopically homogeneous mixture of two or more different species of polymer (see Definition 2.2).
- Notes*
1. In most cases, blends are homogeneous on scales smaller than several times visual optical wavelengths.
 2. For polymer blends, no account is taken of the miscibility or immiscibility of the constituent polymers, i.e. no assumption is made regarding the number of phases present.
 3. The use of the term *polymer alloy* for a polymer blend is discouraged.
- 2.41 network polymer**
polymer network
A polymer composed of one or more networks (see Definition 1.58).
- 2.42 semi-interpenetrating polymer network (SIPN)**
A polymer (see Definition 2.2) comprising one or more networks (see Definition 1.58) and one or more linear (see Definition 1.32) or branched (see Definition 1.33) polymer(s) characterized by the penetration on a molecular scale of at least one of the networks by at least some of the linear or branched macromolecules.
- Note*
Semi-interpenetrating polymer networks are distinguished from interpenetrating polymer networks because the constituent linear or branched polymers can, in principle, be separated from the constituent polymer network(s) without breaking chemical bonds; they are polymer blends.
- 2.43 interpenetrating polymer network (IPN)**
A polymer (see Definition 2.2) comprising two or more networks (see Definition 1.58) which are at least partially interlaced on a molecular scale but not covalently bonded to each other and cannot be separated unless chemical bonds are broken.
- Note*
A mixture of two or more pre-formed polymer networks is not an IPN.

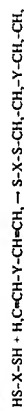
- 2.44 polymer-polymer complex**
A complex, at least two components of which are different polymers (see Definition 2.2).
- 3. REACTIONS**
- 3.1 polymerization**
The process of converting a monomer (see Definition 2.1) or a mixture of monomers into a polymer (see Definition 2.2).
- 3.2 oligomerization**
The process of converting a monomer (see Definition 2.1) or a mixture of monomers into an oligomer (see Definition 2.3).
- Note*
An oligomerization by chain reaction carried out in the presence of a large amount of chain-transfer (see Definition 3.24) agent, so that the end-groups (see Definition 1.35) are essentially fragments of the chain-transfer agent, is termed telomerization.
- 3.3 homopolymerization**
Polymerization (see Definition 3.1) in which a homopolymer (see Definition 2.4) is formed.
- 3.4 copolymerization**
Polymerization (see Definition 3.1) in which a copolymer (see Definition 2.5) is formed.
- 3.5 co-oligomerization**
Oligomerization (see Definition 3.2) in which a co-oligomer (see Definition 2.7) is formed.
- 3.6 chain polymerization**
A chain reaction in which the growth of a polymer (see Definition 1.1) chain (see Definition 1.30) proceeds exclusively by reaction(s) between monomer(s) (see Definition 2.1) and reactive site(s) on the polymer chain with regeneration of the reactive site(s) at the end of each growth step.
- Notes*
1. A chain polymerization consists of initiation and propagation reactions, and may also include termination and chain transfer (see Definition 3.24) reactions.
 2. The adjective *chain* in *chain polymerization* denotes a chain reaction rather than a polymer chain.
 3. Propagation in chain polymerization usually occurs without the formation of small molecules. However, cases exist where a low-molar-mass by-product is formed, as in the polymerization of oxazoline-2,5-diones derived from amino acids (commonly termed amino-acid *N*-carboxy anhydrides). When a low-molar-mass by-product is formed, the adjective *condensative* is recommended to give the term *condensative chain polymerization*.

4. The growth steps are expressed by



where P_x denotes the growing chain of degree of polymerization x , M a monomer, and L a low-molar-mass by-product formed in the case of condensative chain polymerization. The term *chain polymerization* may be qualified further, if necessary, to specify the type of chemical reactions involved in the growth step, e.g., ring-opening chain polymerization, cationic chain polymerization.

6. There exist, exceptionally, some polymerizations that proceed *via* chain reactions that, according to the definition, are not chain polymerizations. For example, the polymerization



proceeds *via* a radical chain reaction with intermolecular transfer of the radical center. The growth step, however, involves reactions between molecules of all degrees of polymerization and, hence, the polymerization is classified as a polyaddition (see Definition 3.8). If required, the classification can be made more precise and the polymerization described as a chain-reaction polyaddition.

3.7 polycondensation

A polymerization (see Definition 3.1) in which the growth of polymer (see Definition 1.1) chains (see Definition 1.30) proceeds by condensation reactions between molecules of all degrees of polymerization (see Definition 1.13).

Notes

1. The growth steps are expressed by



$$(x) \in \{1, 2, \dots, \infty\}; (y) \in \{1, 2, \dots, \infty\}$$

where P_x and P_y denote chains of degree of polymerization x and y , respectively, and L a low-molar-mass by-product.

2. The earlier term *polycondensation* was synonymous with *condensation polymerization*. It should be noted that the current definitions of polycondensation and condensative chain polymerization were both embraced by the earlier term *polycondensation*.

3.8 polyaddition

A polymerization (see Definition 3.1) in which the growth of polymer (see Definition 1.1) chains (see Definition 1.30) proceeds by addition reactions between molecules of all degrees of polymerization (see Definition 1.13).

Notes

1. The growth steps are expressed by



$$(x) \in \{1, 2, \dots, \infty\}; (y) \in \{1, 2, \dots, \infty\}$$

where P_x and P_y denote chains of degrees of polymerization x and y , respectively.

2. The earlier term *addition polymerization* embraced both the current concepts of *polyaddition* and *chain polymerization*, but did not include *condensative chain polymerization*.

3.9 statistical copolymerization

A copolymerization (see Definition 3.4) in which a statistical copolymer (see Definition 2.9) is formed.

3.10 random copolymerization

A copolymerization (see Definition 3.4) in which a random copolymer (see Definition 2.10) is formed.

3.11 alternating copolymerization

A copolymerization (see Definition 3.4) in which an alternating copolymer (see Definition 2.11) is formed.

3.12 periodic copolymerization

A copolymerization (see Definition 3.4) in which a periodic copolymer (see Definition 2.12) is formed.

3.13 ring-opening polymerization

A polymerization (see Definition 3.1) in which a cyclic monomer (see Definition 2.1) yields a monomeric unit (see Definition 1.8) which is acyclic or contains fewer cycles than the monomer.

Note

If the monomer is polycyclic, the opening of a single ring is sufficient to classify the reaction as a ring-opening polymerization.

3.14 ring-opening copolymerization

A copolymerization (see Definition 3.4) which is a ring-opening polymerization (see Definition 3.13) with respect to at least one monomer (see Definition 2.1).

3.15 radical polymerization

A chain polymerization (see Definition 3.6) in which the kinetic-chain carriers are radicals.

Note

Usually, the growing chain end bears an unpaired electron.

3.16 radical copolymerization

A copolymerization (see Definition 3.4) which is a radical polymerization (see Definition 3.15).

3.17 ionic polymerization

A chain polymerization (see Definition 3.6) in which the kinetic-chain carriers are ions or ion-pairs.

Note

Usually, the growing chain ends are ions.

3.18 ionic copolymerization
A copolymerization (see Definition 3.4) which is an ionic polymerization (see Definition 3.17).

3.19 anionic polymerization
An ionic polymerization (see Definition 3.18) in which the kinetic-chain carriers are anions.

3.20 cationic polymerization
An ionic polymerization (see Definition 3.18) in which the kinetic-chain carriers are cations.

3.21 living polymerization
A chain polymerization from which chain transfer and chain termination are absent.

Note
In many cases, the rate of chain initiation is fast compared with the rate of chain propagation, so that the number of kinetic-chain carriers is essentially constant throughout the polymerization.

3.22 living copolymerization
A copolymerization (see Definition 3.4) which is a living polymerization (see Definition 3.21).

3.23 cyclopolymerization
A polymerization (see Definition 3.1) in which the number of cyclic structures in the constitutional units (see Definition 1.14) of the resulting macromolecules (see Definition 1.1) is larger than in the monomer molecules (see Definition 1.3).

3.24 chain scission
A chemical reaction resulting in the breaking of skeletal bonds (see Definition 1.50).

3.25 depolymerization
The process of converting a polymer (see Definition 2.2) into a monomer (see Definition 2.1) or a mixture of monomers.

Note
Unzipping is depolymerization occurring by a sequence of reactions, progressing along a macromolecule (see Definition 1.1) and yielding products, usually monomer molecules (see Definition 1.3), at each reaction step, from which macromolecules similar to the original can be regenerated.

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